ICICLES: Intelligence for Choosing Icy Landing and Exploration Sites

Completed Technology Project (2016 - 2018)

Project Introduction

We propose transformative optical perception capability, inspired by physics-based computer vision principles, for undersea exploration. Submerged caves and other phenomena like geothermal vents present scientifically interesting locations to explore while simultaneously being challenging environments to navigate. If robots exploring ocean worlds are to collect valuable scientific samples and observations, then they must be able to operate in these challenging environments where precise 3D perception is mandatory. Traditional subsurface sensing modalities, like sonar, are predominantly designed for vehicles operating in open oceans. Sonar has coarse, imprecise sensing returns - while it might be able to detect the presence of an object or hazard, precise localization is not possible. It also suffers from multi-path interference on complex surfaces and minimum range issues in tightly constrained spaces, both highly probable features in subsurface caves and ocean floors. These sensing issues preclude current robotic approaches from being able to navigate, explore, and sample with any accuracy. In contrast, optical sensors work best in subsurface settings when they are close to objects of interest. Furthermore, visual sensors give a degree of precision that is not possible with current techniques and produce data of greater scientific value. For example, close-range estimation of range data from multiview geometry would provide a degree of precision not possible with typical beam sensors. Using an understanding of the physical properties of the materials in a scene, a strength of the proposal team, would further increase the accuracy of visual sensors, allowing precise localization of obstacles and science targets, and enabling acquisition of samples that otherwise would not be possible. Visual sensing techniques are a necessary compliment to wide-beam sensing modalities for accurate, reliable, scientific exploration. However, standard computer vision techniques are confounded when the operating environment has significant scattering. Physics-based approaches present possible remedies to this problem, however they have been sparsely investigated for extra-terrestrial ocean-going robots. The proposed investigation extends the boundaries of visual sensing through the scattering media of planetary oceans. We will develop optics for better photography in subsurface environments for 3D perception and science analysis. Active illumination designs separating the source and detector as well as high spatial frequency illumination will be explored. These may be supplemented with multispectral approaches and environmentally adapted frequencies for perception. Novel techniques for dense imaging with sonar and underwater LIDAR/RADAR also hold promise for this investigation. Indirect methods, such as depth through turbidity and sub-pixel refinement from liquid turbulence could enable squeezing of maximal information from visual approaches. Physics-based computer vision enables a sea change in subsurface exploration capabilities. Precision access to submerged caves and ocean floor features permits robots to acquire samples of scientific interest that would otherwise be unattainable. 3D navigation is a crucial bottleneck for subsea scientific exploration and the proposed work addresses this directly.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

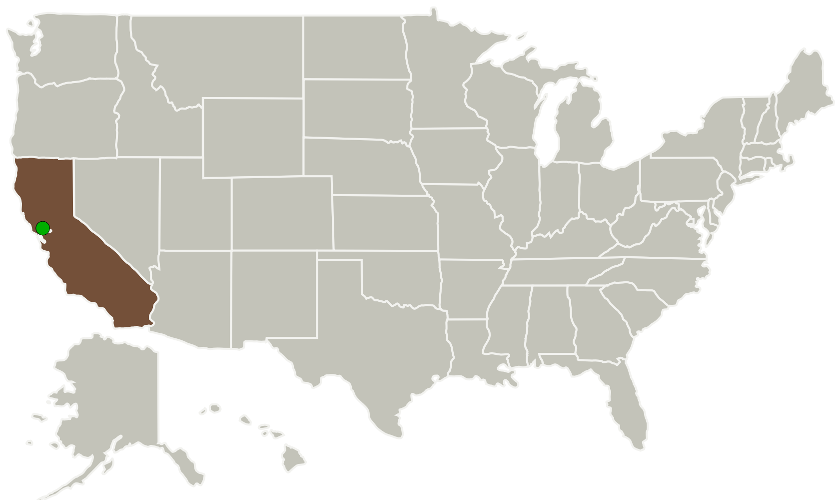
Responsible Program:

Concepts for Ocean Worlds Life Detection Technology

Anticipated Benefits

The results of this project will benefit future landed missions to icy bodies, including Europa and Enceladus, by developing technology to autonomously land on icy surfaces. This reduces mission risk by selecting safe and interesting sites that avoid hazards and increase scientific return.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Carolyn R Mercer

Principal Investigator:

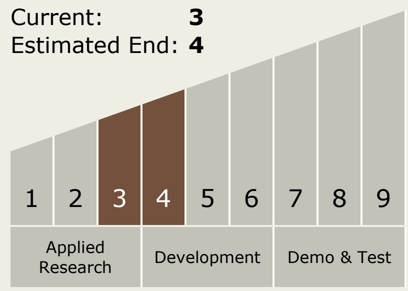
Uland Y Wong

Co-Investigators:

Robert A Duffy
Padraig M Furlong
Michael N Dille

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX04 Robotic Systems
  └ TX04.1 Sensing and Perception
    └ TX04.1.3 Onboard Mapping and Data Analysis

Target Destination

Others Inside the Solar System